

For the First Time—a Complete History for You

At the All-Steel Conference held in Cleveland during February, Mr. Walter S. Goll, Manager of the Fort Wayne Works, presented a history of the "General Electric" Refrigerator, tracing its development, step by step, from the original machine invented by the French monk, Abbe Audiffren, down to the present series of models. His talk gave such a comprehensive and at the same time such a fascinatingly interesting account of the successive advances in our "miracle industry" that a great many of the distributors who had the privilege of listening to it asked that they be furnished with copies of it.

Space does not permit reprinting the entire history in one issue. In order to avoid shortening it and leaving out much valuable information we have arranged, therefore, to run it in "On the Top" in installments. The first appears in this issue. We suggest that you save it and watch for the balance in forthcoming issues.

Refrigerator Development in General Electric Co.

By WALTER S. GOLL,
Manager Fort Wayne Works

Practically every device in general use that contributes to our comforts and conveniences is more or less accepted as a matter of course. The fact remains, however, that the everyday conveniences that we have today such as telephones, automobiles, vacuum sweepers, washing machines, sewing machines, typewriters, incandescent lamps, moving picture machines, radio equipment, X-ray apparatus, were given to the world after long and patient and expensive processes of research and invention and development. These processes are continuing incessantly in order to improve and cheapen these articles and so broaden their sphere of usefulness and make available their blessings to a larger number of our people.

The General Electric icing unit is no exception to this rule, and few of you can have any conception of the long years of investigation and experiment and development and hopes and disappointments which were necessary to give you the article you have today. It is my purpose to review briefly the history of this development and to give you an appreciation, if possible, of the magnitude of the task which has been accomplished.

Something over a quarter of a century ago Abbe Audiffren, a French monk, began a series of experiments in an effort to develop a refrigerating machine which would be rugged, dependable and free from all of the features of conventional machines

which up to that time had been sources of trouble and failure.

We know that he made many models, testing this feature and discarding that, until he finally fixed upon a design which included many novel and ingenious features, most of which were entirely new to the art.

Briefly, it consisted of a hollow shaft, on either end of which was mounted a spherical bronze shell, the whole structure resembling a large dumbbell. In one shell was hung by bearings on that portion of the shaft within the shell a heavy pendulum which, due to the force of gravity, hung approximately vertically at all times.

On this pendulum were mounted two cylinders carried on trunnions and oscillating against a face plate carrying ports which, being alternately closed and opened to similar ports in the cylinders, constituted the intake or suction valves. The cylinders carried pistons operated by straps on an eccentric carried on the shaft.

With the shaft and the spherical shell rotating in bearings and driven by belt from a motor, we had relative motion between the shaft and shell on the one hand and the pendulum and cylinders on the other, thus forming a compressor.

This spherical shell revolved in a tank of cooling water to take out the heat of compression and to condense the refrigerant (SO₂) from a gas to a liquid. The refrigerant was carried through the hollow shaft to the second shell revolving in a tank of brine where it was boiled away, absorbing heat from and cooling the brine and being drawn back by the suction of the pump through the

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shaft to the compressor where the cycle began again.

We had here many of the elements of our present General Electric refrigerating unit, namely a compressor discharging dense gas into shell or case, a condenser (the tank of cooling water) to convert the gas into a liquid, a float valve to control its discharge out of the condenser into an evaporator where the evaporation of the refrigerant cools the tank of brine, which latter in turn was used to freeze ice or cool refrigerator.

And like our unit this machine was exhausted of air and dried out, charged with SO₂ gas and lubricating oil and hermetically sealed.

The only basic difference was that the dumbbell shaft ran in external bearings which required occasional lubrication and was driven by a conventional motor not built into the case.

This device under the name of the Audiffren-Singren refrigerating machine had been built for ten or fifteen years at the plant of Singren at Epinal, France, when, about 1910 a group of Americans headed by Mr. C. A. Griscom, secured the American rights to these patents.

The General Electric Co. agreed to undertake its manufacture for the American Audiffren Refrigerating Machine Co., who contracted to market the product through the Johns-Manville Co.

In order to learn the art of manufacturing so complicated a device Mr. James J. Wood, Works Manager and Chief Engineer of the Fort Wayne Works (a designer and inventor of note) went to France and thoroughly studied the processes of production at the Singren Works.

In 1911 we began the manufacture at Fort Wayne of four sizes of this machine; one-fifth ton, one-half ton, one ton and two ton, and continued at an average annual rate of 150 to 200 machines a year until September, 1928, when this production was transferred to the Builders Iron Foundry, at Providence, R. I.

While Mr. Wood still continued in touch with this development, the actual responsibility for manufacture and test rested upon Mr. Clark Orr, and for contact with the American Audiffren Co. and the Johns-Man-

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ville Co. upon Mr. H. E. Crane, who left our employ in 1925.

These two men, Mr. Orr in particular, devoted themselves to mastering the intricacies of manufacture and test of this device and to the study of thermo-dynamics with the result that a number of improvements and refinements in design and manufacture were introduced from time to time.

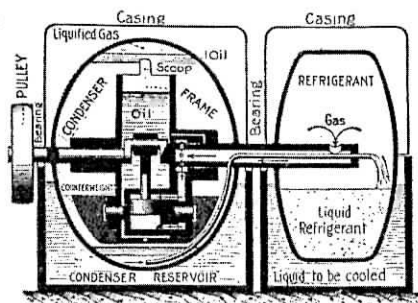
How well Mr. Orr applied himself to this involved and difficult task and with what success is evidenced by the fact that Mr. Wood in 1924 wrote Mr. F. C. Pratt, then Vice President in charge of Engineering and Manufacture, recommending Mr. Orr for the Charles A. Coffin Award of Merit and stated:

"He is not only thoroughly reliable, an excellent, high-grade workman, but a very studious man as well. When he goes home at the end of the day it is to study and see how much better he can perform his work on the day following. As a consequence he has developed until in my opinion he is the most thoroughly posted man in this country on the construction and operation of small refrigerating machines for domestic purposes."

As a result of the experience gained with the Audiffren machine we began in 1915 and 1916 the consideration of a design for a domestic machine. It was early recognized that the Audiffren design was too complicated and inherently too expensive for domestic use. Besides, it required open water cooling and brine tanks, bearings and motor.

All the domestic machines then on the market and those in process of development of which we could learn were investigated and many of them tested. In the sale of fractional horse-power motors, which for many years has been an important part of our production at Fort Wayne, our Sales Department brought in to us for motor application many devices, and this gave us an excellent opportunity to investigate and test many of these early refrigerating machines such as Isko, Coldak, etc.

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of "On The Top")



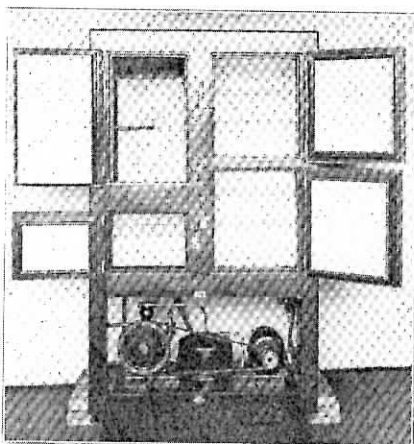
Cross-section of the Audiffren water-cooled refrigeration unit

In the spring of 1917 we made one model (OC-2 Form B) using a single Audiffren oscillating cylinder and eccentric in a cast iron housing taking power through a stuffing box, shaft,

pulley and belt from a conventional motor. These elements, with a water-cooled condenser chamber were mounted on a cast-iron base in the bottom of a refrigerator cabinet and piped to a circular plate evaporator in a brine tank near the top of the cabinet. This outfit also included control mechanism to start and stop the unit with change of refrigeration temperature and to regulate the cooling water supply.

The tests on this model were sufficiently encouraging to justify the building of seven more which were installed, some in the homes of employees of the Company at Fort Wayne and some in the Testing Department.

All through this period and for



One of the early water-cooled models
Type OC-2 Form "B"

many years thereafter we continued to study and test other makes of ma-

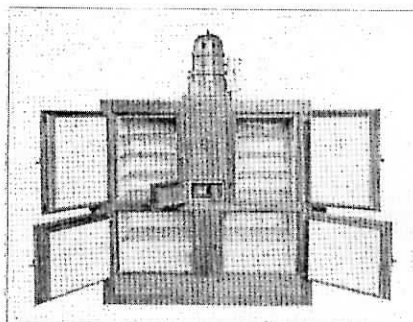
chines, including reciprocating pistons and cylinders, rotaries, gear compressors, absorption types, etc., and as a result we are more and more convinced that the oscillating piston and cylinder design such as we have in our present DR machine is the most efficient and reliable that has been developed at this time.

Some time in 1918 or 1919 some one (I think it was Mr. F. S. Hunting, then Manager of Fort Wayne Works) conceived the idea of a motor built into the compressor case taking the current in through insulated leads, thus obviating the necessity of a stuffing box and making possible a hermetically sealed machine.

In September, 1919, a 400 pound model of this type OC-3 Form E (the

true prototype of the present DR design) was started. It consisted of a vertical cast iron case, water jacketed for cooling, containing a split phase motor with wound stator and squirrel cage rotor similar to the present design running at 1750 r.p.m., mounted on a vertical shaft geared to a compressor shaft running about 500, which latter carried two standard Audiffren No. 2 cylinders, spring snifter valves, pistons, rods, eccentrics and float type expansion valve, all of which had been proven out in Audiffren experience. This case also included in its base water cooling coils for condensing the gas.

The Schenectady Research Laboratory developed the metal glass leads for carrying the current which could be screwed and soldered into the case. This machine was mounted on top of the cabinet and carried below it a copper coil evaporator which was submerged in a brine tank in the upper part of the cabinet. Here we had a hermetically sealed machine, with motor enclosed, and mounted on the top of the cabinet from which it could be easily removed for replacement, the only essential difference from the present design being that it was water cooled.



Early water-cooled General Electric
Refrigerating Unit with
sealed-in motor.

Three additional models were built and the tests were so encouraging that we designed and built five models of a similar 200 pound machine Type OC-2 Form E.

With these nine machines many experiments were made and much useful data secured which from time to time suggested changes and improvements.

In January, 1921, we started to build twenty-five of this Type OC-2 Form E machine, most of which, together with Jewett refrigerator cabinets to match, were installed in the homes of our officials and employees at Schenectady, Erie, Fort Wayne,

Cleveland, Chicago and elsewhere in order that we might get some field experience. With many of these machines were installed instruments to record the energy consumed, the number of starts and stops, etc.

Whenever a machine failed from whatever cause it was returned to the factory for disassembly and examination, which gave us an opportunity to detect defects of design and manufacture and apply a remedy. This was a very valuable and necessary experience as the equipments were in actual service in the hands of the ultimate users.

One of these first units ran for five years without attention.

During these years there were many discouraging and heartbreaking experiences, but as we view them in retrospect we realize now more perhaps than we did then that we were making consistent progress and were demonstrating the soundness of the principles upon which our designs were based.

This was the situation when under date of January 31, 1922, a full report of the history and accomplishment up to that date was made by Mr. Hunting with a recommendation that the commercial exploitation of this device be undertaken on a limited scale. This recommendation was not adopted and the work of experiment and development proceeded with the design of the OC-2 Form G, in which, due to wear and noise in the gears in the Form E, they were eliminated and the compressor mounted on the same shaft with a six pole motor at 1150 r.p.m.

In January, 1923, I made a report to my superiors on the situation with respect to the Audiffren business as well as the domestic unit development and recommended that we either abandon both or proceed immediately to exploit the domestic machine.

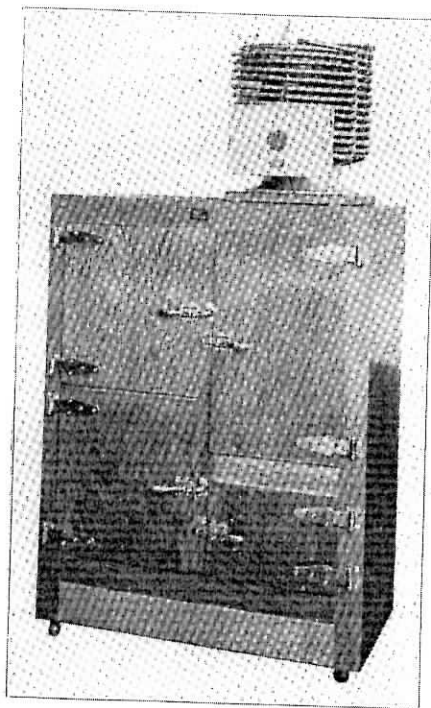
Shortly thereafter (in March, 1923) Mr. Swope and Mr. Pratt com-

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missioned Mr. A. R. Stevenson, Jr., to make a careful investigation and report on the whole domestic refrigeration situation—the possible field for the sale of such a device, what other manufacturers were doing, their successes or failures and an estimate of the value of our developments as compared with our competition.

This task Mr. Stevenson undertook aggressively and in August, 1923, submitted a most exhaustive and complete and illuminating report covering every phase of the situation.

In the meantime at Mr. Pratt's request we had started a model of the



The first air-cooled General Electric Type OC-2, Form "H"

OC-2 Form H machine similar to the Form G except it was to be air cooled instead of water cooled. This machine was in operation in August, 1923, and undergoing various tests.

In September, 1923, at a conference of executives in Schenectady, we were commissioned to build twenty-five Form H air-cooled machines.

At the same time, with Mr. Stevenson's assistance, we began investigations, tests and estimates of cost of the Odin machine made by the Automatic Refrigerator Company of Hartford, Conn., using air as the refrigerant, and the mercury compressor unit made by the Savage Arms Company of Utica, N. Y.

A full report on these machines

compared with our own considering costs, performance, etc., was submitted April 1, 1924, by Mr. Stevenson, in which we again expressed our faith in the superiority of our basic principles of design.

As a result of this report we were authorized to build six additional Form H air-cooled machines and to install three of them in homes of our employees, retaining three in the Laboratory for test.

These air-cooled machines operated at higher temperatures and pressures than their water-cooled predecessors, and this change of conditions introduced new problems in lubrication, insulation in the motor windings, etc., all of which had to be met and solved.

In the solution of all these problems we acknowledge with deep gratitude the heartiest sympathy and co-operation of many of our officials, engineers and the staff of the Research Laboratory at Schenectady, including Messrs. Pratt, Allen, Eveleth, Drs. Whitney, Coolidge and Langmuir, Steenstrup, Stevenson, Merrill, Dantszen and many others.

On February 14, 1925, I made a further report reviewing the experience in test and in service with these air cooled machines and secured immediate approval to start the manufacture of one hundred machines to be sold in Fort Wayne and Cleveland.

At a conference at Association

Island in July, 1925, the whole situation was reviewed with a group of our executives and it was decided to equip the Winter Street Plant and to manufacture 10,000 OC-2 Form H units in 1926.

Deliveries were begun in the fall of 1925 and continued through a part of 1926.

The problems and difficulties of building up an organization to produce these machines in even limited quantities were interesting. The correct solution of the problem of lubrication, proper drying of the gas, the evacuation and charging of the units is largely credited to the ingenuity of Mr. Orr and Mr. Steck who had been

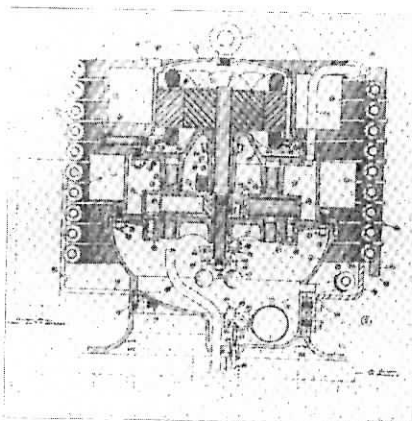
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added to the engineering staff, and Mr. Holz as Superintendent of the factory.

In the meantime, and very fortunately, Mr. Eveleth, then Manager of Schenectady Works, had become deeply interested in this whole program and he and Mr. Allen had enlisted the interest of a number of Schenectady engineers in the problem of improving our OC-2 designs or of developing new ones.

Out of all this effort Mr. Steenstrup produced the DR-2 design, including the smooth-coil condenser, the substitution of the crank for the eccentrics, the use of a single cylinder, the square type hydrogen brazed evaporator, the improved float valve, the pressure oil feed and unloader, the spring mounting and many other refinements which permitted manufacture in quantity with uniformity of product and gave us a sightly and salable product.



Cross-section of DR-2 Unit
OC-2

In other words he took the basic principles of design and operation which Fort Wayne had demonstrated as sound and worthy of elaboration and wrought them into a workable and dependable device.

Too much credit cannot be given for this contribution of Mr. Steenstrup, for in my judgment it converted this whole project from a probable failure into an assured success.

In 1926 Schenectady equipped for the manufacture of this DR-2 machine and began deliveries in October of that year, since which time up to January, 1929, approximately 180,000 units have been produced. This great task has been accomplished by a group of enthusiastic men under the guidance of Messrs. Eveleth, Vice-

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president, and Delchak, Works Manager, this group including Messrs. Steenstrup, Spicer, Walker, Spain and others.

In addition Schenectady has developed the DR-1, a smaller unit, and a bottle water cooler using this same unit, and has equipped to produce from 4000 to 5000 per week of this size.

In January, 1927, Fort Wayne began the manufacture of DR-3 units, since when approximately 35,000 have been produced.

For the manufacture of motors for all these units, wherever manufactured, Fort Wayne has set up a separate department with conveyors and improved equipment which have already given substantial cost reductions.

Some time ago, Schenectady, thru Mr. Merrill's department developed a very superior "all steel" cabinet and began its manufacture in the smaller domestic size. Within the last few months a new factory has been equipped at Erie to meet demands for this type of cabinet in

other sizes. Mr. J. L. Knight, head of the Refrigerator Cabinet Engineering Department is responsible in a large degree for the high standard of quality and production of this "All Steel" cabinet.

In June, 1928, Fort Wayne was commissioned to develop a DR-4 having twice, and a DR-5 having three times the capacity of the DR-3 to be used for commercial applications. The DR-4 was secured by using two DR-3 cylinders instead of one and the DR-5 by using two DR-3 cylinders of increased bore. Of course it was necessary to develop new motors, frames, evaporators and other parts and to provide increased condenser capacity.

This task has been completed with

the exception perhaps of a few details, and these units have been thoroughly tested in all the conditions we believe they will be called upon to meet. In addition they have been tested on a number of commercial applications and are ready for your inspection.

Throughout all of this parallel development at Schenectady and Fort Wayne there has been a fine spirit of harmony and co-operation between the two engineering and manufacturing organizations.

Nor can I refrain here from paying high tribute to the work of Mr. A. R. Stevenson, Jr., who as the personal engineering representative of Mr. Pratt and later of Mr. Allen, has acquired a broad and valuable knowledge of the whole program in its

many phases, has contributed many valuable analyses and suggestions, and has done much to promote the high degree of co-operation which has marked the relations of the several groups concerned in this development.

All of this latter development at Fort Wayne has been made under the able direction of Mr. Morganthaler, my assistant in charge of engineering since December, 1925, and a corps of engineers he has built up within the last few months, including, in addition to Messrs. Steck, Orr and Holz, Messrs. Woodruff and Whitesel, transfers from Schenectady, and a number of younger men.

We have developed at Fort Wayne an able, aggressive organization and

a spirit of co-operation which we hope will be useful to you gentlemen in the field.

This ability, such as it is, is available to you and anxious to serve you, and we hope you will avail yourselves of these facilities.

I cannot close without expressing for myself (and I know I reflect the sentiment of the whole organization at Fort Wayne) our profound admiration for the outstanding accomplishment of the commercial organization (Messrs. Quinn, Zimmerman, and all their associates) and our appreciation of the cordiality and frankness which has marked all our dealings with them.